DRAFT - Grow Beast Article – DRAFT (7-30-2013)

**Introduction**

***Introduce the GB scenario.***

What do you do when you need an extended graphing activity that will get your middle-level math students to sit up and pay attention? You want them to make choices about their learning, to measure with a purpose, to record the data, use T-tables and enter the data as points in an x-y scatter plot. You want them to see the line that emerges as a story about something real. You want them to do all this not because you told them to but because they have an authentic need to *use* the data. They *need* to make predictions! They *need* to understand these concepts and develop these skills because … *dinosaurs*!

… Or more specifically, grow beasts. Grow beasts are not a specific product; the name refers to a class of products made by a host of manufacturers. Some are dinosaurs but others are bugs, sea creatures, lizards and just about everything else that can be molded from this special substance, a superabsorbent hydrophilic (water-loving) polymer. This is much the same stuff you will find if you slice open a disposable diaper. Its key feature is that it absorbs liquid. In a diaper it is formulated so as to do this very quickly. In a grow beast the process takes days. Remove the grow beast from the liquid and it begins to shrink as the liquid evaporates. They do this in water. They do it in milk. They do it in coffee. They’ll do it in root beer if you give them a chance. But in each of these liquids they grow – and shrink - differently. Therein lies one of the keys to success in this activity.

***Establish LTs and make connections to CCSS, NCTM standards and relevant literature***

In this unit we aim for the development of skill and understanding in three related areas. First we want students to develop through iterative experience their understanding of how mathematics may be used to analyze, represent, and predict change. This is an aspect of mathematical modeling, one of the eight standards for mathematical practice specified in the Common Core State Standards (CCSS, 2010). Second, and as a means to enable the first goal, we want students to develop their skill in plotting points in the Cartesian plane. Finally, tying these two together, students will learn about the use of graphs as a means of representation and communication in mathematics. Both representation and communication have been emphasized by the NCTM Standards (NCTM, 2000). This unit fits well in the curriculum employed in middle grades. One of the 6th grade Common Core standards requires students to “Represent and analyze quantitative relationships between dependent and independent variables.“ (CCSS p. 44).

If students are to use graphs effectively as a means of representation and analysis they must have a clear and intuitive grasp of this tool and the meaning of points situated in the Cartesian coordinate system. They must understand a line or a curve in the Cartesian plane as the depiction of an ongoing relationship between one variable, x, and another, y, for example, between elapsed time and the length of a growing dinosaur. This understanding of graphs and their relationship to functions is not always present, even among students at the college level (Van Dyke and White 2004), a fact that gives further legitimacy to this unit. The activities are structured and sequenced so as to stimulate personal involvement and commitment, activate prior knowledge of representation and communication of data and results, and scaffold the development of conceptual understanding of mathematical analysis and prediction. We also aim to provide a vehicle for repeated practice with targeted skills such as measurement and the plotting of points.

Underlying the entire unit is an overt emphasis on the development of a productive disposition toward mathematics (NRC, 2001 p. 131). We want students to be genuinely and creatively interested in the math they do and to develop a sense that with diligence and effort they can learn useful mathematical skills that enable them to make sense of situations that matter to them.

**Overview of the Investigation**

***Brief description of the sequence of activities and a quick introduction to the instructional setting.***

This six-day unit of instruction took place in two all-girls classes of 6th graders. Students were introduced on Monday to the grow beasts and to the central question: “How big will they get by Friday?” They got to know their beasts, naming them, drawing them, creating their back-stories and generally developing an emotional attachment and commitment to the context of the mathematical investigation. As the unit got underway this commitment served to sharpen and sustain students’ focus on the mathematical concepts and skills. They measured, recorded data, used proportional reasoning to make predictions and discussed the relative merits of different methods to make these predictions. As the unit progressed students were each given their own grow beast which they grew in a liquid of their own choosing. This gave them opportunities for additional data analysis and representation as they compared and discussed different growth rates. As the unit drew to a close the teacher engaged the students in additional activities designed to help them generalize the understanding and skills they were developing in this specialized context.

**The Instructional Activity** (KB / MR)

*Monday*

In this 90-minute block the class activities were designed to address three goals: (1) to get to know the grow beasts; (2) to build and solidify their understanding of graphs as a way to record and communicate measurements; and (3) to determine how to accurately measure and record the grow beast’s growth.

We began the class with a short introduction to grow beasts including what they are and how they work. A central question emerged: “How big will they get by Friday?” We wrote this on the board. Students were then arranged into groups of four and each team was given a grow beast. Their team tasks were to name their beast, to use their collective imagination to determine its favorite food and activity, to make up a brief story about it, and to predict how big their grow beast would grow by Friday. Each team completed these tasks and recorded their answers in a team booklet.

This activity was followed by a brief discussion of students’ prior knowledge of graphs, the x and y axes, and how graphs tell a story about a set of data. We discussed as a class how to best keep track of the grow beasts’ growth using a graph, and ideas about how the graph would help us make data-driven predictions. At the end of class we would discuss how to set up the graph, but because our learning target for the day was to familiarize students with plotting points on a graph, we wanted to give them the opportunity to physically interact with a graph. We adapted a lesson plan from the College Preparatory Math curriculum (*Making Connections Course One, Lesson 4.1.2)* engaging students in creating a human graph.

The last activity of the day focused on measuring to the nearest millimeter and why it mattered that our measurements were precise. We returned to our earlier discussion of how to set up a graph for recording a grow beast’s growth over time. Presented with a few different options for organizing the graph, students quickly agreed that the days of the week should be on the x-axis, and the length in centimeters on the y-axis. Each group was given a graph already generated in this way to glue into their booklet. Then they measured their group’s grow beast to the nearest millimeter, and plotted that point on their graph. The most exciting part of the day came when students placed the grow beast in a bucket of water.

Day 2

The excitement that bubbled in the room on day two was contagious as students crowded around the grow beasts to see how much they had grown over night. With rulers in hand, students were directed to measure their grow beast and record the time and length in a t-table in their booklet and then plot the point on their graph. We asked students to determine how much time had passed since the end of the previous day’s class to the beginning of today’s class without using pencil or paper. This activated students’ mental math and provided an opportunity to share different strategies for computing time. Next, students discussed as a class how much their grow beast would grow by tomorrow’s class using the data they collected today. Then, within their group they were asked to make predictions for how many centimeters they thought their grow beast would be on Thursday and Friday. Students plotted their predictions on their graph and were given the chance to share them with the class on the document camera. The next task was to create a class graph on chart paper upon which each group would record their grow beast’s growth, allowing the class to easily view and compare the different growth rates of the grow beasts and to use as a platform for discussing appropriate scale when setting up graphs. The teacher drew and labeled the graph using the think-aloud method (need to mention more about cognitive apprenticeship?) “If the paper is 30 centimeters high, and I think my grow beast will grow up to 15 centimeters, I can make my interval marks every two centimeters.” Each group placed their data on the graph using a different colored marker. The final activity of the day was a short activity about different types of graphs, namely linear and non-linear, and the stories they tell. (Include what the homework was? Graphing pairs of integers) Finally, students were primed for receiving their individual grow beast and reminding them to bring in the liquid of their choice. Available to them would be grape juice, lemonade, and Coke.

*Day 3*

After measuring, recording and plotting the data from group grow beasts both on the class chart and in the group booklets, the class began working on the individual grow beast project. Students were really excited to take ownership of their own grow beast’s fate, and had brought in interesting liquids including Red Bull energy drink, Windex, orange juice, and rubbing alcohol. Just like the group grow beast, students created their own little booklet to record information about their own grow beast. They were given time to write a short story and draw a picture of their beast, and many students poured creatively over their booklets, making intricate family histories for their small polymer pets. They made a data page and used rulers to construct their own graph, thinking carefully about scale. They left two pages for a conclusion and further questions. Students measured their beast, placed it in their liquid of choice, and input their data on the t-table and graph.

*Day 4*

Class began with students measuring, recording, and plotting the growth of their grow beast in the handmade booklets and marking the growth of their group’s dinosaur. The variety of liquids students had chosen for their individual grow beasts naturally led to a conversation comparing the differing growth rates. Having recently completed a unit on ratio, rates, and proportions, we were excited to see students compute their dinosaur’s growth rate by dividing the difference in centimeters from yesterday to today by the total number of hours (ex. 1.3cm/24hours). Some students wanted to get even more specific and were able to find the growth rate per hour. Once students computed their grow beast’s growth rate, the class discussed how different liquids effect the growth rate. The richness of this discussion was a testament to the power of bringing science into the math classroom; because students cared about the hands-on experiment in which they had ownership and purpose, math became a meaningful tool they used to support their ideas and observations. Next, students practiced making and reading graphs by filling in data about their own lives. They made a t-table for things like age and hair length, time of day and minutes exercised, day of the week and minutes spent on technology, etc. They gave their finished data table to a partner to graph the data and summarize the results. This lesson helped students become more comfortable with plotting points, organizing and representing data. Since the data came from their own lives, students again were using data and graphing to learn about their peers.

*Day 5*On day 5 of the unit students measured and recorded their group’s dinosaur for the last time. Using the large class graph we had created on day 2, students analyzed how different groups had grow beasts that had different growth patterns. Some grew a lot at first, and then tapered off, while others had more of a steady growth over the course of the week. Students also measured and recorded their individual dinosaur and made predictions about how much it would grow over the weekend. The lesson of the day was about how to graph different situations in which measurement played a key role. The class was divided into three groups and explored a different scenario that required graphing: (1) Circumference of a balloon vs. the number of breaths blown into it (2) number of handfuls vs. the number of unifix cubes in the handful and (3) the distance a toy car traveled from the end of the ramp vs. the height of the ramp. Each group was asked to carry out their experiment and graph their results. This gave way to sharing the different types of graphs (linear vs. non-linear).

*Follow-up*

Over the weekend, students’ individual grow beasts continued to grow in size (although some stayed the same depending on the liquid). Students were excited to make their final measurements, record, and plot their data in the booklet. They wrote a conclusion about the experiment, which included comparing the different growth rates of both group and individual grow beasts. After completing a final graphing activity in which they worked with a partner to read, interpret, and create various graphs (including price of fuel over time, swim meet results for different swimmers, and cell phone use while driving over time), students reflected on their learning. ( I didn’t save the surveys, so maybe I shouldn’t include this piece since there isn’t any data about it….?) My memory says that students did master the learning targets we set out, and that almost all students felt that they understood much more about how to make and read graphs.

Thoughts on conclusion?

**Conclusion**

**Katherine – You can stop reading here. ☺ Thanks!**

.… Our goal is always to enable students to use mathematics – and to see themselves as capable of using mathematics - as a way to make better sense of the world. Students who are successful with this unit have taken a step toward that level of mathematical proficiency. ….

**References**

Common Core State Standards

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National Research Council (NRC) (2001). *Adding it up: Helping children learn mathematics.* J. Kilpatrick, J. Swafford, and B. Findell (Eds). Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

National Research Council (2000). *How People Learn: Brain, Mind, Experience and School*. Washington, DC: National Academy Press.

Van Dyke, Francis, and Alex White. (2004)“Examining Students’ Reluctance to Use Graphs.” Mathematics Teacher. volume 98, number 2 p.110-17.

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**EXTRA STUFF:**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_excised from the science version of your “Mathematizing” talk:

Ok, your middle schoolers are not likely to extend or revise much of existing science but they can engage in their own evidence-based and theory building activities. They can do that! And when they do, research tells us that they are more likely remember and to transfer to new settings. (See Chapter 3 “Learning and Transfer” in the NRC’s (2000) book, “How People Learn.”)

The NCTM has identified “Representation” as one of its ten Standards for School Mathematics (NCTM 2000, p.67). In the 3 -5 grade band students are called to “*represent and analyze patterns and functions using words, tables, and graphs (NCTM 2000, p.158).* Likewise in the Common Core State Standards one of the 6th grade standards requires students to “Represent and analyze quantitative relationships between dependent and independent variables. “ (CCSS p. 44). They are to analyze relationships between variables using graphs, tables and equations. Further, one of the standards for mathematical practice across all grades is modeling with mathematics, that is, representing aspects of the world quantitatively in order to understand them more fully and answer questions (CCSS 2010 p. 7).

One of the most basic mathematical tools for representation of functional relationships between variables is the x-y graph, most often displayed on a Cartesian plane. If students are to use graphs effectively as a means of representation they must have a clear and intuitive grasp of this basic tool and the meaning of points situated in the Cartesian coordinate system. They must understand a line or a curve in the Cartesian plane as the depiction of an ongoing relationship between one variable and another, for example, between age and height. This understanding is not always present, even among students at the college level (Van Dyke and White 2004).